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Fourth Bi-Monthly Progress Report

on

Contract NAS 5-3907

This fourth bi-monthly progress report covers the time period from 3 December 1964 to 3 February 1965. Pilot experiments were conducted in order to examine the predictability of solar data found in IGY Solar Activity Report series Number 17 dated May 1, 1962. Analysis of these data reveal that there were about 1.75 importance 3 flares, 7.75 importance 2+ flares and 63.3 importance 1+ flares for every importance 3+ flare occurring in 1957. Relative to this same datum, there were 0.5 importance 3+ flares, 1.125 importance 3 flares, 5.375 importance 2+ flares, 7 importance 2 flares, 26.75 importance 2^- flares and 42 importance 1+ flares in the year 1958. A suitable data base was arbitrarily taken to include flares of importance 2^- and greater, these being encoded into an 8-symbol language by doubling the importance number and counting + as an additional unit. The environment contained no temporal information other than the order of flare occurence.

In the first experiment, a magnitude-of-the-difference error-weight payoff matrix was used. That is to say, a prediction of the importance of each next flare is based upon the importance of the preceding flares and their temporal order with the penalty for incorrect predictions being equal to the magnitude of error. 40 flares were taken as the initial recall. Of the first 300 predictions 57.7% were correct, these predictions being made by a one-state machine which quickly evolved to demonstrate the statistical dominance of importance 2^- flares and that importance 3 flares are best predicted by persistence (that is, they may be expected to be followed by another flare of similar importance). In order to evaluate the significance of this result, another computer program was written which would predict these same data on the basis of the maximum marginal probability, the maximum first-order conditional probability, the maximum second-order conditional probability, and any of these with the program choosing that one which had highest score up to that time. After the first 300 predictions, these conventional techniques showed scores ranging from 55.4% up to 56.1%; this highest score being achieved by the maximum marginal predictor. Thus, it would seem that the evolutionary program had discovered a suitable logic for predictions in that its score was slightly superior than this score. Unfortunately, this ability is not considered to be significant because no particular capability has been demonstrated for the successful prediction of the more important flares.

In order to improve this situation, another experiment was conducted in which the error-cost matrix reflected a linear weighting in favoring the more important flares. Reference Table I.

TABLE I

	2^-	2	2^+	3	3^+
2^-	4	5	6	7	7
2	5	3	4	5	6
2^+	6	4	2	3	4
3	7	5	3	1	2
3^+	7	6	4	2	0

As a result, within the last 50 predictions 18 of the 27 importance 2^- flares, 2 of the 12 importance 2 flares, one of the 8 importance 2^+ flares were properly predicted. Neither of the 2 importance 3 flares were properly predicted and the only importance 3^+ flare was properly predicted. It would appear that the evolutionary program was still not placing sufficient weight on the relative importance of correctly predicting the large flares.

To further improve the situation, another experiment was performed on these same data with the error cost matrix shown in Table II.

TABLE II

	2^-	2	2^+	3	3^+
2^-	9	10	11	12	13
2	11	4	5	6	7
2^+	12	6	2	3	4
3	13	7	4	1	2
3^+	14	8	6	3	0

A penalty of .01 was used. Analysis of the results reveal that 26.8% of the 2^- flares were correctly predicted, 45.1% were incorrectly predicted as being of importance 2, 24.6% were incorrectly predicted as importance 2^+, 1.7% were incorrectly predicted as being of importance 3 and 2.3% were incorrectly predicted as importance 3^+. Of the importance 2 flares which occurred, 23.1% were incorrectly predicted as importance 2^-, 57.0% were correctly predicted, 18.5% were incorrectly predicted as being 2^+, and 15.4% were incorrectly predicted as being 3. Of the importance 2^+ flares which occurred, 20.4% were incorrectly predicted as being of importance 2^-, 50% were incorrectly predicted as being of importance 2, 27.3% were correctly predicted, and 2.3% were incorrectly predicted as being of importance 3. Of the importance 3 flares which occurred, 50% were incorrectly predicted as being 2^-, 25% were incorrectly predicted as being 2 and 25% were correctly predicted. Of the importance 3^+ flares which occurred, 16.7% were incorrectly predicted as being 2^-, 50% were incorrectly predicted as being 2 and 33.3% were incorrectly predicted as being 2^{+}.

It is apparent that further adjustment of the error cost matrix is desired; however, the adjustment of the error-cost matrix already achieved demonstrates a significant improvement in that the predominance of the least importance flares is mitigated as a factor in determining the sequence of predictions. In general, this revised description of the goal generally encourages false alarms as opposed to missed flares. Further efforts to improve the predictability of these data were not made because of the practical importance of predicting both the magnitude and the time of occurence of each next flare.

During this same time period, an effort was made to assemble a suitable data base for the meaningful prediction of real-world data relevant to flares and other solar activity. In this regard a number of significant difficulties were encountered.

In the hope of finding suitable data already assembled, contact was made with Miss D. Trotter of the High Altitude Observatory, Boulder, Colorado. She furnished a series of reports entitled "Solar Activity Summary" (HAO-42 through HAO-54, except for HAO-48) covering the time period from January 13, 1958 to January 7, 1961. These reports describe active regions and present tabular data concerning major flares and the accompanying radio noise. Unfortunately, the regions are significantly large so that they may simultaneously contain a number of separate plages. Miss Trotter was kind enough to provide her personal assistance by separately identifying the Mc Math numbers for the plages within each region; however, it would be difficult to separate the flare data contained in these reports into the associated plages. Further, few flares are reported within each listing.

As a result of a request to Mr. D. Robbins of NASA/Houston, the draft of a forthcoming report for solar activity for Calendar Year 1958 was received and copied (the original being returned to him). This report catalogues plage data, flare data, sun spot data, and additional terrestrial effects. Analysis of these data allowed the compilation of the data contained in Table III which lists the plage family, individual plage data, and flare data within that plage. Specifically, the plage family number designates a particular plage which may survive several rotations of the sun. For example, plage family 2 was first identified with McMath plage #4355 which was later identified as plage 4440, then as plage 4445, and lastly as plage 4483. Throughout this history from January 11.5 through April 4.5 (CMP Gr. Day) a total of 12 flares were separately identified. These ranging in importance from 1 through 3. Most of the families were less suitably identified in terms of the number of flares even though some had many more rotations.

TABLE III

PLAGE DATA										FLARE DATA					
Plage Family	McM. Plage No.	CMP Gr. Day	Mean Long.	Mean Lat.	Ave. Int.	Max. Area	No. Flares	Age In Rotation	Identi-fication	Gr. Day	Beg. UT	End UT	Max. UT	Imp.	Position
1	4347	7.0	78°	N13	3	13000	22	3	4296	Jan 07					
2	4355	Jan 11.5	19°	S12	3.5	9000	33	1	NEW	Jan 07	1820	1939	1832 1842	2	S18E39
	4355									Jan 15	1640	1757	1642	2+	S13W58
	4400	Feb 8.5	24°	S12	3.5	25000	91	2,3	4355 4356 4360 4362	Feb 09	1330	1501	1341	1+	S20W02
	4400									09	2108	2302	2142	2+	S12W14
	4400									10					
	4400									10	1320	1411	1332	2+	S13W64
	4400									10	1900	2030	1911	1+	S14W64
	4445	Mar 7.5	15°	S15	3	10000	45	3,4	4400	Mar 03	1005	1411	1020	3	S16E60
	4445									Mar 05	0500	0632	0540	3	S12E46
	4445									Mar 14	1454	1541	1507	2	S21W85
	4483	Apr 4.5	6°	S22	3	5000	33	4,5	4445	Apr 02	1951	2025	1954	1+	S15E23
	4483									Apr 06	1929	2025	1940	1	S15W27
	4483									06	0301	0408	0309	1	S17W44
3	4368	16.5	313°	S07	3	6000	3	1	NEW	Jan 17 18	2253	2335	2256	1	S11W32
4	4370	17.5	300°	N15	2.5	6000	26	1	NEW	Jan 16	1414	1447		1+	N16E23
5	4377	20.5	261°	S14	2	3000	6	3	Part of 4319	Jan 16	2255	2347	2306	2	S15E47
	4372	20.5	261°	S24	2	3500	10	4,5	4318 4319	Jan 25	0915	1107	1005	3	S23W70
6	4426	22	193°	S16	3	6000	6	7	4382	Feb 26	0527	0632	0550	2	S18W61
7	4436	25	153°	S12	3.5	1400	15	1	NEW	Mar 01	0905	1007	0917	3	S11W45
8	4444	7	22°	N31	2.5	4000	18	1	NEW	Mar 09	1540	1740	1546	2	N34W32
	4484	Apr 4.5	6°	N30	3	9000	48	2	4444	Mar 29	1339	1410	1343	2	N35E78
	4484									Mar 30	0045	0123	0108	2	N35E74
	4529	May 2	3°	N22	3	14000	60	3,5	4484 4485	May 2					
	4529									May	2025	2115	2035	1+	N24W50
										5	2032	2115	2037	1+	S15W39
	4578	30	352°	N24	3	8000	47	4,6	4529	Jan 04	2147	2356	2152	2	N14W58
	4578	May 30								Jan 05	0835	0956	0850	2+	N15W65
	4578									06	0436	0614	0448 0505	2	N16W78

TABLE III (Cont'd.)

9	4449	12	316°	N12	2.5	9500	31	3	4410	Mar 11	0030	0042	0034	1	N11E12
	4449									Mar 12	0024	0233	0037	2+	N08E02
10	4465	22.5	177°	N21	3	7000	66	1	NEW	26	0036	0040		1	N21W50
	4465									Mar 28	1833	1922	1838	2	N20W85
	4465									29	1630	1637	1632	1+	N21W90
11	4469	Mar 25	144°	N25	3	6000	19	1	NEW	29	1447	1507	1449	1	N26W70
12	4476	28.5	98°	S12	3.5	15000	90	2	4442a	Mar 23	0947	1445	1005	3+	S14E76
	4476									Mar 30	0944	1421	1000	2+	S16W20
	4476									Mar 31	0005	0036	0014	2	S17W22
	4476									Mar 31	0038	0130	0052	2	S06W23
	4476									Mar 24	1607	1643		1	S15E57
	4476									Mar 25	0557	0626	0603	2	S15E50
	4476									Mar 27	1534	1710	1552	2+	S16E23
	4476									Mar 28	1703	1904	1714	2+	S15E09
13	4478	30	78°	S22	3	6000	29	2	4438	Mar 28	1030	1152	1038	2	S24E26
	4478									Mar 29	2042	2131	2047	2	S24E21
	4478									Mar 29	1819	1915	1823	2	S24E08
14	4493	9.5	300°	N16	3	5000	34	2	4453	Apr 07	1010	1215	1025	3	N14E32
15	4508	Apr 21.5	141°	S21	3.5	7500	30	1	NEW	Apr 21					
16	4519	26	349°	N09	3.5	6000	6	1	NEW	Apr 30	b 1932	2015	1940	1+	N10W50
17	4530	3	82°	S15	3.5	11000	77	1	NEW	Apr 30	a 1930	2005	1940	1+	S17E27
	4530									May 1	2115	2241	2130	3	S18E15
	4530									May 5	0356	0457	0415	3	S16W29
18	4548	15.5	184°	S21	3.5	13000	49	2	4516	May 15					
	4598	June 11.5	187°	S20	3	7000	10	3	4548	June 05	1615	1656	1631	2+	S18E69
	4636	08	196°	S22	3.5	8000	42	4	4598	June 04	1712.5 1747.5	1722.5 1755	1717.5 1750	1- 1-	S23E32 S23E32
19	4596	10	207°	N28	3.5	10000	30	1	NEW	June 10					
	4634	07.5	203°	N28	3	9000	23	2	4596	June 07	0020	0414	0110	3+	N25W08
	4634									June 12	2317	2330	2330	1	N26W78
20	4597	10	207°	N43	3	7000	77	1	NEW	June 10					
21	4607	June 18	101°	N12	3.5	7000	52	3	4563	June 14	2112	2146	2118	1	N14E38
	4607									June 19	0940	1210	1010	3	N14W21

TABLE III (Cont.d)

22	4618	26.5	1°	S16	3	11000	15	3	4579	June 26					
23	4622	29	315°	S19	3.5	7000	38	2	4581	June 29					
24	4659	July 26.5	311°	S19	3	20000	112	3	4622	July 29	0259	0408	0304	3	S14W44
	4659									July 29	0458	0526	0458	1	S14W38
	4659									July 30	1523	1637	1530	2	S13W64
	4659									July 31	1058	1150	1122	1+	S13W77
	4659									Aug 2	1840	1851	1841	1-	S14W90
	4710	22	321°	S15	3	9000	12	4	4659	Aug 22	1032	1210	1043	1+	S14W90
	4712	Aug 24	294°	S18	3	7500	15	4	4659	Aug 28	1025	1045	1030	2	S18W65
	4765	19.5	305°	S18	3.5	17000	58	5	4712 4710	22	0730	0910	1750	2	S19W42
25	4623	29.5	309°	N12	3	12000	16	1	NEW	June 26	0245	0517	0306	2+	N10E49
	4623									June 27	0254	0405	0308	1+	N10E37
26	4630	July 05	236°	N24	3	11000	39	1	NEW	July 03	0041	0114	0050	1+	N30E37
	4630									July 04	0513	0534	0517	1+	N29-E26
	4667	Aug 02	225°	N27	3.5	15000	27	2	4630	July 04	0409	0610	0435	3	N30W31
27	4646	18	64°	N09	3	5500	40	1	NEW	July 18					
28	4651	21	24°	N22	2.5	8500	21	1	NEW	July 19	1905	2030	1908	2+	N23E13
29	4665	31	252°	N04	3.5	12000	30	2	4631	July 25	0000	0128	0043	2+	N10E85
30	4670	04	199°	S09	3.5	5000	31	1	NEW	Aug 04	2112	2127	2114	1	S07W10
	4722	31	202°	S09	3.5	12000	54	2	4670	Aug	b 1028	1047	1030	1	S09E38
31	4686	12.5	86°	S13	3.5	11000	72	2	4653	Aug 07	1457	1700	1508	3	S16E71
	4686									Aug 14	2137	2225	2203	1+	S14W36
	4686									Aug 16	0433	0831	0440	3+	S14W50
	4739	08	96°	S20	3	14000	17	3	4684 4686	Sept 07	1639	1726	1643	2	S32E18
32	4708	22	321°	N18	3.5	8000	60	3	4657	Aug 19	2118	2411	2256	2	N18E26
	4708									Aug 20	0042	0128	0045	2+	N16E18
	4708									Aug 22	1428	1717	1450	3	N18W10
	4708									Aug 26	0025	0124	0027	3	N20W54
	4756	17.5	331°	N17	3	9000	26	4	4708	Sept 17					
33	4741	Sept 09	83°	S07	3	7000	57	1	NEW	Sept 02	2102	2141	2105	1+	S08E84
	4741									Sept 14	0822	1030	0835	2+	S10W80

TABLE III (Cont'd.)

34	4743	9.5	76°	N17	3	6000	17	1	NEW	Sept 09					
35	4750	14.5	11°	S10	3	9000	20	2	4703	Sept 18	0728	0938	0830	3	S11W53
36	4764	20	298°	N23	3.5	6000	22	3,4	4711	Sept 20					
37	4777	24	245°	N30	3	3000	7	1	NEW	Sept 28	2046	2108	2054	1-	N32W66
38	4781	30	166°	S10	3.5	7500	22	1	NEW	Oct 02	2143	2201	2148	1	S06W38
39	4806	Oct 10.5	27°	N13	3.5	3000	6	2	4748	Oct 08	1510	1528	1522	1-	N12E25
40	4826	20.5	255°	S02	3.5	6500	50	1	NEW	Oct 21	2316	0127	2330	2+	S04W22
	4826									Oct 24	1432	1801	1457	2+	S05W57
41	4829	22.5	229°	S10	3	9000	36	2	4779	Oct 22					
	4877	18	240°	S12	3	11000	4	3	4829	Nov 14	0036	0207	0046	3	S19E51
42	4838	Oct 27.5	163°	S30	2	2000	5	1	NEW	Oct 23	1655	1803	1728	1	S32E50
43	4849	Nov 3.5	71°	S15	3	6000	49	1	4817	Nov 03					
	4897	Nov 30.5	75°	S18	2.5	12000	31	3	4849	Nov 30					
	4934	28	73°	S17	3.5	10000	48	4	4897	Dec 23	0545	0730	0624	2+	S15E66
	4934									Dec 31	1656	1741	1703	3	S18W54
44	4851	3.5	71°	N08	3	5500	11	1	NEW	Nov 03					
45	4883	24.5	154°	S12	3.5	12000	34	1	NEW	Nov 24	1607	1907	1621	3	S11W06
46	4884	25.5	141°	N22	3	6000	33	1	NEW	Nov 27	1857	1909	1859	1	N18W12
	4884									27	2354	0020	2356	1	N19W19
47	4898	Dec 02	55°	N15	2.5	7500	8	3,4	4854	Nov 30	2240	2308	2250	1-	N13E22
	4898									Dec 09	1642	1735	1654	1	N10W90
48	4911	Dec 09.5	316°	N16	3	9000	31	1	NEW	Dec 09					
49	4913	12	283°	S03	3.5	9500	69	3	4873	Dec 10	0219	0306	0221	2	N01E20
	4913									Dec 10	1312	1514	1318 1428	1	S03E18
	4913									Dec 11	1545	1612	1550	1-	S02E00
	4913									Dec 11	1640	1707	1647	1-	S02E10
	4913									Dec 11	1705	1745	1720	1-	S02E00
	4913									Dec 11	1802	1842	1812	2	S02E00
	4913									Dec 11	1850	1917	1857	1-	S02W02
	4913									Dec 11	1930	2012	1939	2	S02E02
	4913									Dec 12	1229	1547	1304	2+	S03W08
	4913									Dec 15	1535	1550	1538	1-	S04W49
	4913									Dec 17	1040	1115	1041	1	S04W82
50	4905	Dec 5.5	9°	S07	2.5	3000	5	1	NEW	Dec 11	1740	1755	1745	1-	S07W88
51	4919	15	244°	N10	3	5000	10	1	NEW	Dec 17	1855	1927	1900	1+	N07W35
52	4936	29	59°	N16	3.5	15000	30	4,5	4898	Dec 29					

In order to attack this problem, attention was turned to "National Bureau of Standards List of IGY Flares with Normalized Values in Importance And Area" by C. S. Warwick, Series #17 dated May 1, 1962. This report covers the same time period as the above reference data and was examined in detail in the hope that a more complete listing of the associated flares could be obtained. Unfortunately, decisions on many of the listed flares were difficult to make in that no obvious basis was available for determining the particular extent and shape of the plage at the time of the considered flare. To illustrate, flare 5464 shown to occur at 58 01 14 0732 17534W was judged to fall outside of the relevant plage domain even though it is only about 10 degrees away from the expected position.

Table IV indicates those flares which appear to have been associated with the second plage family. All of the flares indicated to exist within this family in Table III were not exactly identified. Further, certain discrepancies were noted between the listings furnished by Robbins and Warwick. In any event these data appeared to be unsuitable as a basis for prediction because of the significant absence of that half of the information which is generated on the far side of the sun. In view of the present difficulty in obtaining such information, it is considered more suitable to examine data

Table IV

FLARE NO.	YR	MO	DA	FIRST BEG	LAST END	COR IMP	AREA SQ DEG	MEAN LAT	MEAN CMD
5296	58	01	07	0304	0313	1-	.7	18S	41E
5297		"		0315	0322	1-	1.5	16S	45E
5298		"		0413	0434	1-	1.5	16S	44E
5299		"		0858	0905	1-	-	17S	45E
5303		"		1820	1939	2-	8.6	16S	39E
5311	58	01	08	0141	0151	1-	1.5	13S	48E
5315		"		0751	0800	1-	1.0	14S	42E
5318		"		1731	1746	1-	.8	18S	44E
5322		"		1935	1941	1-	.3	12S	33E
5323		"		2008	2013	1-	.4	16S	41E
5336	58	01	09	1029	1038	1-	3.5	17S	32E
5337		"		1116	1143	1-	1.4	19S	29E
5343		"		1506	1524	1	2.8	10S	25E
5344		"		1525	1552	1-	2.4	13S	25E
5348		"		1546	1552	1-	.4	12S	23E
5352		"		1930	1947	1-	.6	15S	28E
5353		"		2142	2202	1-	.5	11S	20E
5365	58	01	10	0843	1000	1	1.8	16S	17E
5373		"		1106	1151	1-	2.0	15S	11E
5375		"		1321	1342	1-	1.3	14S	18E
5381		"		1628	1644	1-	.6	15S	07E
5387		"		2120	2145	1-	2.6	13S	11E
5388		"		2212	2222	1-	.7	15S	04E
5397	58	01	11	1657	1717	1-	1.4	12S	01W
5398		"		1722	1742	1	2.6	16S	03W
5399		"		1810	1836	1-	-	15S	01W
5401		"		1902	1947	1	4.6	11S	04W

Table IV (continued)

FLARE NO.	YR	MO	DA	FIRST BEG	LAST END	COR IMP	AREA SQ DEG	MEAN LAT	MEAN CMD
5890	58	02	09	1330	1501	1+	6.7	20S	01W
5900	58	02	10	0834	0845	1-	-	22S	08W
5908		"		1256	-	1-	-	21S	11W
5913		"		1540	1617	1-	2.0	22S	14W
5916		"		1900	1907	1-	.4	17S	23W
5926	58	02	11	0745	0817	1-	1.9	20S	25W
5932		"		0915	0919	1-	.6	17S	38W
5934		"		0941	1035	1-	.9	19S	46W
5985	58	02	13	1018	1110	1+	3.8	18S	49W
5997	58	02	14	1223	1231	1-	.7	16S	57W
6003	58	02	15	0158	0216	1	-	15S	67W
6006		"		0711	0732	1	.8	22S	72W
5896	58	02	09	2108	2302	2	13.5	11S	15W
5916	58	02	10	1900	1907	1-	.4	17S	23W
5937	58	02	11	1319	1342	1-	1.0	23S	25W
5938	58	02	11	1342	1542	1+	5.4	22S	27W
5958	58	02	12	0937	1012	1+	4.9	21S	35W
5902	58	02	10	0917	0918	1-	-	13S	69W
5909		"		1320	1411	2-	3.5	13S	65W
5915		"		1900	2030	1+	3.1	12S	64W
5928	58	02	11	0820	0836	1	.4	13S	80W
5946		"		2237	2247	-	.8	18S	86W
•				•		•		•	
•				•		•		•	
•				•		•		•	

Table IV (continued)

FLARE NO.	YR	MO	DA	FIRST BEG	LAST END	COR IMP	AREA SQ DEG	MEAN LAT	MEAN CMD
5402	58	01	12	0630	0651	1	2.9	18S	09W
5403		"		1236	1248	1-	2.2	16S	15W
5410		"		1424	1527	1-	1.4	11S	12W
5411		"		1443	1453	1-	.4	18S	14W
5417		"		1927	1935	1-	.6	17S	16W
5439	58	01	13	2037	2047	1-	1.1	11S	40W
5444		"		2215	2232	1-	.6	11S	41W
5446		"		2232	2241	1-	.6	14S	42W
5450	58	01	14	0034	0041	1-	.4	15S	43W
5454		"		0140	0148	1-	.4	15S	43W
5457		"		0230	0238	1-	.6	16S	52W
5460	"	"		0301	0306	1-	.6	15S	44W
5462		"		0543	0608	1-	.6	14S	44W
5465		"		0955	1010	1-	-	15S	44W
5468		"		1351	1400	1-	1.5	13S	41W
5470		"		1540	1755	1+	3.6	16S	43W
5472		"		2142	2215	1	1.8	18S	42W
5473	58	01	15	0056	0106	1	.5	11S	58W
5476		"		0500	0641	1	3.4	13S	53W
5478		"		0747	0755	1-	1.3	13S	55W
5481		"		1017	1032	1	1.6	13S	54W
5485		"		1640	1757	3-	8.5	14S	58W
5489		"		2056	2102	1-	.8	12S	65W
5490		"		2106	2118	1	.6	10S	66W
•				•		•		•	
•				•		•		•	
•				•		•		•	

which occurs within a single crossing of the solar disc in greater detail in the belief that information derived from the eastern hemisphere will prove helpful in the prediction of proton events which occur in the western hemisphere. The decreased likelihood of the occurrence of such events in the eastern hemisphere serves to indicate that such prediction might possibly require additional data gathered in terms of other parameters such as plage age, shape, intensity, the nature and number of sun spots and the magnetic intensity. Such data can be more readily obtained on a daily basis and might even be found for each 6 hour time interval. For example, daily sun spot data is provided by Robbins in terms of the Zurich classification as well as the Mt. Wilson type. Unfortunately, some of these latter data appear to be missing. Hopefully, they can be derived from the Zurich classification and other relevant data.

The search for a suitable data base is continuing. Contact has been made with personnel of the Lockheed Observatory and with Dr. Fred Ward of AFCRL. In the meantime, experiments are continuing to increase the efficiency and suitability of the available evolutionary program.

During the reported time period, 75 man hours and about 1.177 hours IBM computer time were used.